

Fulvia (Fulvia) nienkeae spec. nov., a new *Fulvia* from the Central Indo-West Pacific (Bivalvia, Cardiidae)

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Fulvia (Fulvia) nienkeae spec. nov. (Cardiidae) is described from various localities in the Central Indo-West Pacific. It is compared with the similar, sympatric *Fulvia (Fulvia) australis* (G.B. Sowerby II, 1834) and with the Pliocene *Fulvia (Fulvia) tegalense* (Oostingh, 1934) comb. nov.

Key words: Bivalvia, Cardiidae, *Fulvia*, new species, Indo-Pacific.

INTRODUCTION

The genus *Fulvia* J.E. Gray, 1853, originated in the Oligocene (Schneider, 1995) and has an Indo-Pacific, Japonic, south Australian, African and Mediterranean distribution (Ter Poorten, 2009). It has a littoral-sublittoral bathymetric range. At present 16 extant species are recognized (Bouchet et al., 2012) of which the size ranges from circa 10 to 100 mm. Due to the paucity of differentiating gross morphological characters (i.e. ribs: poorly developed if at all; rib ornamentation: virtually absent; outline: often rather variable) identification of the species in the genus *Fulvia* frequently poses considerable problems. A major step to clarify this situation was presented

in the review of *Fulvia* by Vidal (1994), followed by Vidal & Kirkendale (2007), in which several additional species were described. Among others, subtle differences in the lunular area, local presence or absence of minute granulations, degree of rib development on various parts of the shell and nature of the colour patterning have proven to be the most useful characters in species segregation. Not surprisingly, the taxonomy of *Fulvia* is still far from resolved, as exemplified by the fact that several of the recently introduced taxa have been synonymised (see Bouchet et al., 2012 for an overview) or given different generic allocation (Ter Poorten, 2009).

Vidal (1994: 106) mentioned three forms of *Fulvia (Fulvia) australis* (G.B. Sowerby II, 1834), based on differences in shape, rib number, size, coloration and ecological preferences. Largely basing his opinion on recent MNHN surveys to New Caledonia, Vidal (1994) claimed that, because of the presence of many intermediate forms, even at the populational level, none of these could be given subspecific or specific status.

In the last two decades, rapidly increasing amounts of new material have become available, enabling the present author to further evaluate the findings of Vidal. Examination of numerous Indo-West Pacific samples, supplemented

with DNA research, has shown that the third form should now be regarded as a distinct species.

Unless stated otherwise, the used morphological terminology follows Vidal (1994).

Acronyms and abbreviations: ANSP, Academy of Natural Sciences Philadelphia, U.S.A.; MNHN, Muséum national d'Histoire naturelle, Paris, France; NHMUK, The Natural History Museum, London, U.K.; RMNH, Netherlands Biodiversity Center Naturalis, Leiden, The Netherlands; TP, colln J.J. ter Poorten, Hilversum, The Netherlands; WAM, Western Australian Museum, Welshpool, Australia; ZMA, Zoological Museum Amsterdam, now part of NBC Naturalis, Leiden, The Netherlands.

For shell characters: H, height; L, length; l.v., left valve(s); p.v., paired valves; r.v., right valve(s); v. valve(s); W, width

SYSTEMATIC PART

Family Cardiidae Lamarck, 1809

Subfamily Laevicardiinae Keen, 1951

Genus *Fulvia* J.E. Gray, 1853; subgenus *Fulvia*

Fulvia J.E. Gray, 1853: 40. Type species by monotypy: *Cardium apertum* Bruguière, 1789; Recent, 'l'Océan Asiatique' & 'Jamaïque' (Indo-West Pacific; Jamaica in the original publication was in error).

Diagnosis. – Shell small (10 mm) to very large (100 mm), generally rather thin shelled, occasionally slightly translucent, rounded to obliquely ovate, equilateral to inequilateral with posterior part more or less expanded. Ribs generally rather low to hardly defined on median part. Ribs unsculptured, only bearing periostracal insertions and occasionally few calcified tubercles in juveniles near postero-dorsal margin. Posterior radial groove often present. Shell surface often partly covered with minute granulations, sometimes commarginally aligned. Animal with guard tentacles on incurrent and excurrent aperture, carrying ocular organs on their tips.

Distribution. – Oligocene to Recent (Schneider, 1995: table III), west African, south African, Mediterranean, Indo-Pacific, Japonic, south Australian; littoral-sublittoral on mud

and sand bottoms, often in association with seagrass or coral rubble.

Remarks. – Vidal (1994) introduced subgenus *Laevifulvia* in order to differentiate a number of relatively small (H up to 20 mm) Indo-Pacific taxa that are lacking periostracal insertions. Pending phylogenetic research (currently undertaken by N. Herrera and S. Steppan, Department of Biological Science, Florida State University, U.S.A.) based on combined morphological and DNA data, both subgenera are herein retained.

Fulvia (Fulvia) nienkeae spec. nov. (Figs 1-2, 6-13, Tables 1-3)

Fulvia (Fulvia) australis (Sowerby, 1834) form 3 – Vidal, 1994: 106, pl. 2 figs 3a-b

Fulvia (Fulvia) spec. aff. *australis* (G.B. Sowerby II, 1834) – Ter Poorten, 2009: 53, pl. 12 fig. 10

Fulvia (Fulvia) aff. *F. australis* (G.B. Sowerby II, 1834) – Ter Poorten in Poppe, 2011: 33, 224, pl. 1107 figs 6-7

Description. – Shell up to circa 37 mm high, elongate-quad-rangular (H/L 1.01-1.15, mean 1.08, $n = 17$), inflated (W/L 0.69-0.77, mean 0.72, $n = 17$), rather thin-shelled, glossy and weakly inequilateral. Umbo prosogyre. Circa 60 (range 54-68, mean 60, $n = 16$) low rounded radial ribs, persistent on all parts of the shell but posteriorly stronger developed. Interstices small, becoming wider anteriorly, of irregular size posteriorly. Lunular heart large and sharply bordered, elevated and larger in right valve. Lunular area large, broad and smooth, with a slightly concave, well delimited ventral border and a slightly sinuous dorsal margin. Hinge arched, characteristic of the genus, teeth fragile, cardinals unequal in size in both valves, not connected, laterals thin, tip of posterior a little bit further away from main cardinal than anterior. Margin finely crenulated. Granulations nearly always absent, if present limited to a few on the lunular area. Periostracum radially well developed along rib flanks (anterior and median part) and rib crests (posterior slope), leaving periostracal insertions when worn off. Exterior usually vividly coloured, cream or yellowish mottled with a pattern of triangular purple-brown patches. Umbonal tip deep purple, lunular heart orange-brown to purple, lunular

	Cat. No.	Height (mm)	Length (mm)	Width (mm)	W/L ratio	H/L ratio	No. of ribs
Holotype	MNHN 25275	33.2	30.3	21.5	0.71	1.10	60
Paratype 1	MNHN 25276	36.3	32.5	23.4	0.72	1.12	62
Paratype 2	MNHN 25277/1	33.8	31.1	22.7	0.73	1.09	60
Paratype 3	MNHN 25277/2	27.0	25.0	17.3	0.69	1.08	60
Paratype 4	MNHN 25278	29.2	27.4	19.5	0.71	1.07	59
Paratype 5	MNHN 25279	29.1	28.7	20.2	0.70	1.01	60
Paratype 6	MNHN 25280	27.2	26.8	18.0*	0.67	1.01	68
Paratype 7	WAM S78192	27.1	23.5	16.8*	0.71	1.15	56
Paratype 8	WAM S78183	30.4	29.7	21.0*	0.71	1.02	57
Paratype 9	WAM S10587	28.4	26.3	18.3	0.7	1.08	54
Paratype 10	ANSP 203969	30.1	28.7	21.2	0.74	1.05	59
Paratype 11	RMNH (ex ZMA)	34.8	31.0	23.8	0.77	1.12	–
Paratype 12	TP 3204	31.4	28.8	20.0	0.69	1.09	57
Paratype 13	TP 1540	37.2	33.3	23.7	0.71	1.12	62
Paratype 14	TP 3184	26.4	24.0	18.0	0.75	1.10	60
Paratype 15	TP 1258	29.1	27.0	20.2	0.75	1.08	62
Paratype 16	TP 3538	35.7	33.1	23.3	0.70	1.08	57
Mean values					0.72 (n=17)	1.08 (n=17)	60 (n=16)

Table 1. Shell measurements of *Fulvia (Fulvia) nienkeae* spec. nov. * extrapolated

area white to yellowish. Interior generally white with a yellow-orange umbonal cavity and a pink to brown posterior slope.

Animal (observed from dried soft parts) with siphonal apertures bordered by tentacles, most of which carrying dark ocular organs on their tip.

Distribution. – Known from the Philippines, Malaysia, Indonesia, Palau, Papua New Guinea, Solomon Isls., Australia, Vanuatu and New Caledonia (Fig. 13). The Australian sample has a question mark on its label behind its supposed Queenslandic origin and thus needs confirmation. Mainly found sublittoral, alive in a bathymetric range of 9–64 m, with empty-shell records encountered up to 95 m (two records from ‘50–150 m’ and ‘100–150 m’ considered too non-committal to be included). Its preferred habitat seems to consist of sand and silt bottoms, not uncommonly in lagoonal environments, sometimes in association with seagrass.

Etymology. – Named after my wife Nienke ter Poorten for her enduring love and support.

Remarks. – Vidal (1994: 106) described his form 3 of *F. (F.) australis* (G.B. Sowerby II, 1834) as follows: ‘shells of rather large size for the species, almost symmetric, more globular (W/L up to 0.80), lightly coloured with or without darker stripes, with a large number of ribs (50–68), and no or rare granules. They are found mainly in the lagoon [New Caledonia] at water depths from 15 to 80 meters and exceptionally in the littoral zones.’ This description clearly matches *F. (F.) nienkeae* spec. nov. See Table 2 for differences in shell morphology with *F. (F.) australis*. Although the geographic distribution of *F. (F.) nienkeae* is completely sympatric with *F. (F.) australis*, the bathymetric distribution largely differs, as the former largely occupies sublittoral habitats whereas the latter is restricted to the littoral zone (see Table 3; Ter Poorten, 2009: table 11).

Despite the highly polymorphic nature of *F. (F.) australis*, material with characters intermediate between both species has not been encountered. The consistently higher rib count and other morphological differences as summarized in Table 2

Character	<i>Fulvia (Fulvia) nienkeae</i> spec. nov.	<i>Fulvia (Fulvia) australis</i> (G.B. Sowerby II, 1834)
Shell shape	elongate-quadragular (circular when juv.), often only weakly inequilateral	variable, but commonly slightly oblique-ovate, habitually clearly inequilateral
Size	H up to 37 mm	H generally up to 30 mm (rarely 35 mm), often smaller
Microscopic granulations	absent	nearly always to some extent visible on anterior slope
Lunular heart	broad, well developed and demarcated, larger in right valve (Figs 1f, 2c)	small, raised and elongate, habitually equally sized in left and right valve (Figs 4-5)
Lunular area	large sized, well delimited and slightly concave margin (Figs 1f, 2c)	medium sized, generally vaguely delimited, only by difference in colour (Figs 4-5)
Radial ribs	54-68	34-55
Median ribs	small and low but still clearly developed	very superficial
Posterior ribs	weakly irregular strength	strongly irregular strength
Internal posterior coloration	posterior slope always pink to brownish	generally not differentiated from other parts
Umbonal cavity coloration	generally yellow-orange, sometimes with a darker coloured umbonal ray	often a purple umbonal ray on yellow, orange or purple background

Table 2. Comparative summary of characters (based on adult material).



Fig. 13. Central Indo-West Pacific distribution of *Fulvia (Fulvia) nienkeae* spec. nov. as currently known.

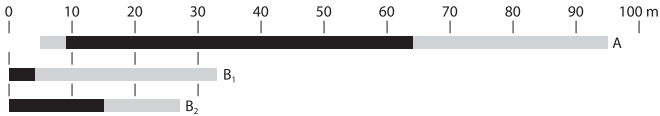


Table 3. Bathymetric ranges of *Fulvia (Fulvia) nienkeae* spec. nov. and *F. (F.) australis* (G.B. Sowerby II, 1834). **A**, *F. nienkeae* spec. nov., all examined material: alive 9-64 m (black, 6 samples), dead 5-95 m (grey, 20 samples); **B₁**, *F. australis*, MNHN Panglao Marine Biology Project 2004 (covered depth range 0-150 m): alive 0-4 m (black, 4 samples), dead 0-33 m (grey, 20 samples); **B₂**, *F. australis*, MNHN Santo Marine Biodiversity Survey 2006 (covered depth range 0-1285 m): alive 0-15 m (black, 16 samples), dead 0-27 m (grey, 13 samples).

are substantial enough to differentiate both taxa.

Due to strongly allometric growth juveniles (Figs 9-10) are much more rounded or obliquely ovate, resembling juveniles of *F. (F.) australis*. However, also juveniles can be separated by their higher rib count, absence of granulations, more pronounced periostracal lamellae (Fig. 1d) and thinner shell. In addition, the background colour of *F. (F.) nienkeae* is darker. *Cardium varium* G.B. Sowerby II, 1834, was described from 'Swan River, N. Holland' (= Australia, Western Australia, Perth, Swan River). This locality is most probably erroneous: Huber & Ter Poorten (2007) have demonstrated that another cardiid from this alleged locality in fact occurs in the Japan-China-Taiwan area. The slightly obliquely ovate outline and the colour pattern are clearly in agreement with *F. (F.) australis*, which only reaches the offshore reefs of northern Western Australia (Willan, 2005). Later on, G.B. Sowerby II (1840: [1]) placed *C. varium* in the synonymy of *Cardium tenuicostatum* Lamarck, 1819, a *Fulvia* species that is restricted to the southern half of Australia.

Cardium pulchrum Reeve, 1845, was described from China. All three syntypes (NHMUK 1978136) are figured by Hylleberg (2011: 929). The obliquely ovate outline and the colour pattern perfectly match that of *F. (F.) australis*.

Laevicardium (Laevicardium) tegalense Oostingh, 1934, described from the Pliocene of Java, Indonesia, clearly belongs in *Fulvia (Fulvia)* (comb. nov.) and is close to *F. (F.) nienkeae* spec. nov. However, the anterior half of the former is largely covered with granulations, it has a rib number of 47-53 and a maximum height of 42 mm; allowing for an easy separation. It can be distinguished from *F. (F.) australis* by its more pronounced and raised lunular heart. *F. (F.) tegalense* may be ancestral to *F. (F.) nienkeae* and *F. (F.) australis*.

Molecular analysis undertaken by N. Herrera and S. Steppan (Department of Biological Science, Florida State University, U.S.A.) has demonstrated a clear genetic separation of *F. (F.) nienkeae* spec. nov. (MNHN 25276, ex IM-2007-43103) from *F. (F.) australis* (MNHN IM-2007-30159). The genetic distances between both samples are as follows:

16S rRNA; uncorrected ('p') distance matrix 9.14%,
corrected ('p') distance matrix (using GTR+G model)
11.68%.

Nuclear (histone H3 and 28S rRNA); uncorrected ('p') distance matrix 1.87%, corrected ('p') distance matrix (using GTR+G model) 1.96%.

The sequences of the holotype (MNHN 25275, ex IM-2007-43104) and paratype 1 (MNHN 25276, ex IM-2007-43103), consisting of histone H3, 16S rRNA and 28S rRNA genes, will be deposited in GenBank. The same counts for sequences of *F. (F.) australis* (Vanuatu, SANTO 2006 stn. DR13, MNHN IM-2007-30159).

TYPE SERIES (INDICATED IN BOLD TYPE)
AND OTHER MATERIAL EXAMINED

Philippines, Bohol, Panglao Isl., 40-52 fms (73-95 m), mud, 08.02.1964. Mariel King Expedition II Sulu Sea MV 'Pele' 1964, 1 v. (WAM S78192, **paratype 7**); Bohol, Balicasag Isl., 2004, 1 p.v. (TP 3204, ex colln G.T. Poppe, figured in Ter Poorten, 2009: pl. 12 fig. 10, **paratype 12**); Bohol, Jetafe (= Getape), Pandanan Isl., Amuseum, 'Guphil I', 05.08.2007. Leg. G.T. Poppe, no. 407645, 1 p.v. (TP 3538, **paratype 16**); Cebu, Olango Isl., Ziczac Point, 10°13.773'N 124°3.407'E, dived at night-time, c. 20 m, 'Guphil I', 05.2006. Leg. G.T. Poppe, no. 329844, 1 p.v. (TP 3184,

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Figs 1-5. *Fulvia (Fulvia)* spp. discussed in this paper. **1-2**, *Fulvia (Fulvia) nienkeae* spec. nov. **1a-f**, New Caledonia, Grand Passage, 19°49.8'S 163°47.7'E, 31-36 m, alive, 27.04.2008. Leg. P. Bouchet & P. Lozouet, CONCALIS, stn. CC2931, holotype, MNHN 25275, H 33.2 mm (a: l.v. exterior, b: l.v. interior, c: r.v. interior, d: detail r.v. antero-ventral slope, e: r.v. hinge, f: dorsal view). **2a-c**, New Caledonia, Grand Passage, 19°56.5'S 163°50.1'E, 28-30 m, alive, 27.04.2008. Leg. P. Bouchet & P. Lozouet, CONCALIS, stn. CC2929, paratype 1, MNHN 25276, H 36.3 mm (a: l.v. exterior, b: r.v. interior, c: dorsal view). **3-5**, *Fulvia (Fulvia) australis* (G.B. Sowerby II, 1834). **3**, Philippines, Panglao, lagoon near Doljo Point, 9°33.3'/9°34.6'N, 123°43.9'/123°43.4'E, fine sand with seagrass, 2 m, 14.06.2004, PMBP 2004 stn. R44, MNHN, H 24.1 mm, r.v. hinge. **4**, Philippines, Mindanao, Southern Dinagat Isl., dived on sand, 15 m, 2007. Leg. G.T. Poppe, colln TP 3550, L 24.3 mm, dorsal view. **5**, Vanuatu, S.E. Matewulu, 15°22.9'S 167°11.9'E, 3-5 m, 28.09.2006, SANTO 2006 stn. DR76, MNHN, L 23.7 mm, dorsal view.





paratype 14); Mindanao, Balut Isl., '100-150 m', 2005, 1 p.v. (colln G.T. Poppe 287751, figured in Ter Poorten, 2011: pl. 1107 fig. 6); Mindanao, Aliguay Isl., near 08°44'0.39"N 123°12'40.73"E, sand, sandy gravel and sandy mud bottoms, '50-150 m' 2004, 1 p.v. (colln G.T. Poppe 220731, figured in Ter Poorten, 2011: pl. 1107 fig. 7).

Malaysia, Sabah State, N.W. coast, 21 m, alive, 10.2006, 1 p.v. (colln M. Huber).

Indonesia, Raja Ampat Isls., Batang Pele Isl., 0°17.812'S 130°12.329'E, 09.04.2001, Raja Ampat Islands Marine RAP Survey 2001, stn. RAI/01/40. Leg. F.E. Wells, 1 p.v. (WAM S10587, **paratype 9**); N. Sulawesi, Manado, shipwreck, 01°31'59.76"N 124°49'39.6"E, 38 m, sandy bottom, 29.11.2008. Leg. S.E.T. van der Meij, stn. Men.05 / mei08/05, 1 v. (RMNH, ZMA.MOLL.407583, **paratype 19**).

Caroline Isls., Palau, 2 mi. N.E. of C. Gamadaguru Isl., on N. tip of Gamudoko Isl., 07°17'45"N, 134°21'30"E, 22.08.1955, stn. 444. Leg. Albert J. Ostheimer III, 1 p.v. (ANSP 203969, ex colln Natural Science Foundation, **paratype 10**).

Papua New Guinea, Madang, off northern end Tah Isl., 06.1987, stn. 9. Leg. F.E. Wells, 1 v. (WAM S78183, **paratype 8**); New Britain, Rabaul, 09.1976, 1 p.v. (TP 1402, ex colln K. Lamprell); New Britain, Escape Bay, Rabaul, 15 m, 1977, 1 p.v. (TP 1540, **paratype 13**).

Solomon Isls. 1 p.v. (TP 2255, ex colln K. Lamprell); Guadalcanal Isl., Honiara, near Point Cruz, in black sand and silt, 5 m, 1992, 1 p.v. (TP 167,

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Figs 6-12. *Fulvia* (*Fulvia*) *nienkeae* spec. nov. **6a-b**, New Caledonia, Grand Passage, 19°49'S 163°48.4'E, 37 m, alive, 09.08.1994. Leg. Métivier, Richer-ORSTOM, BATHUS 4, stn. CC (lagoon), paratype 2, MNHN 25277, H 33.8 mm (a: l.v. exterior, b: r.v. interior). **7a-b**, Philippines, Balicasag Isl., 2004, paratype 12, TP 3204, H 31.4 mm (a: l.v. exterior, b: r.v. interior). **8a-b**, Papua New Guinea, New Britain, Escape Bay, Rabaul, 50 ft (15 m), dead, 1977, paratype 13, TP 1540, H 37.2 mm (a: l.v. exterior, b: r.v. interior). **9**, Vanuatu, Segond Channel, vicinity of Maritime College, 15°31.7'S 167°09.4'E, 9-13 m, 12.09.2006, SANTO 2006 stn. ED05, MNHN, L 13.7 mm, l.v. exterior. **10**, Same stn., MNHN, L 14.1 mm, l.v. exterior. **11a-b**, Philippines, Bohol Isl., N. side, Jetafe, Pandanan Isl., Amuseum, 05.08.2007. Leg. G.T. Poppe, paratype 16, TP 3538, H 35.7 mm (a: l.v. exterior, b: r.v. interior). **12a-b**, Vanuatu, S.E. corner of Espiritu Santo, SANTO 2006 (mixed illegible or confused labels), paratype 5, MNHN 25279, H 29.1 mm (a: l.v. exterior, b: r.v. interior).

ex colln J. & A. Kengalu); Honiara, in black sand in dead reef between seagrass, 6 m, 1991. Leg. A.M. Kengalu, 1 p.v. (TP 1258, **paratype 15**); Honiara, by local divers, 1992, 2 p.v. (TP 2254, ex colln R.P.A. Voskuil).

Australia, Queensland (?), 1 p.v. (RMNH, ZMA.MOLL.407584, ex colln Hessel 38641, **paratype 11**).

Vanuatu, Espiritu Santo, Turtle Bay, 15°21.4'S 167°12.8'E, 29-58 m, alive, 27.09.2006, SANTO 2006, stn. AT38, 1 p.v. (MNHN IM-2007-30150), 4 p.v. (MNHN, no reg. number, juv., partly broken); Bruat Channel 15°37.0/37.2'S 167°09.7/09.9'E 50-64 m, 10.10.2006, SANTO 2006, stn. AT74, 2 v. (MNHN, no reg. number, smallest v. ventral margin def.); Segond Channel, 15°31.7'S 167°10.8'E, 36-43 m, 12.10.2006, SANTO 2006, stn. AT80, 1 v. (MNHN 25280, **paratype 6**); Segond Channel, 15°31.7'S 167°09.7'E, sand, 20-25 m, 15.09.2006, SANTO 2006, stn. DR23, 2 p.v. (MNHN 25278, 1 juv., **paratypes 4, 17**); Segond Channel, 15°31.7'S 167°09.4'E, vicinity of Maritime College, 9-13 m, grey mineral sand, alive, 12.09.2006, SANTO 2006, stn. ED05, 4 p.v., 2 v. (MNHN, no reg. number, juv., partly broken); S.E. corner of Espiritu Santo, SANTO 2006 (mixed illegible or confused labels), 1 p.v. (MNHN 25279, hole in left v., **paratype 5**).

New Caledonia, Grand Passage, 19°49'S 163°48.4'E, 37 m, alive, 09.08.1994. Leg. Métivier, Richer-ORSTOM, BATHUS 4, stn. CC (lagoon), 2 p.v. (MNHN 25277, with dried tissue, **paratypes 2-3**), 1 v. (MNHN 25278, **paratype 18**); S. lagoon, 22°46.6'S 166°53.5'E, 44 m, coarse white sand with foraminiferans, 07.1985, CAMPAGNE no. 9, stn. 557, 1 p.v. (MNHN, figured in Vidal, 1994: pl. 2 figs 3a-b); Grand Passage, 19°56.5'S 163°50.1'E, 28-30 m, alive, 27.04.2008. Leg. P. Bouchet & P. Lozouet, CONCALIS, stn. CC2929, 1 p.v. (MNHN 25276 [ex IM-2007-43103], **paratype 1**); Grand Passage, 19°49.8'S 163°47.7'E, 31-36 m, alive, 27.04.2008. Leg. P. Bouchet & P. Lozouet, CONCALIS, stn. CC2931, 1 p.v. (MNHN 25275 [ex IM-2007-43104], **holotype**).

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